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Presentation to **39th Annual**
Gun/Ammo & Missiles/Rockets Conference

Deconstruction of Fuze Well Guidance Requirements

April 14, 2004

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Synthesis of Course Correcting Fuze Design

Corrects major errors incl
- **Inherent Gun laying errors**
- **Muzzle Velocity Variation**
- **MET errors**

Determine best Solution Space to developing a fuze well based guidance package to provide first shot accuracy < 50 meters

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Derived Requirements

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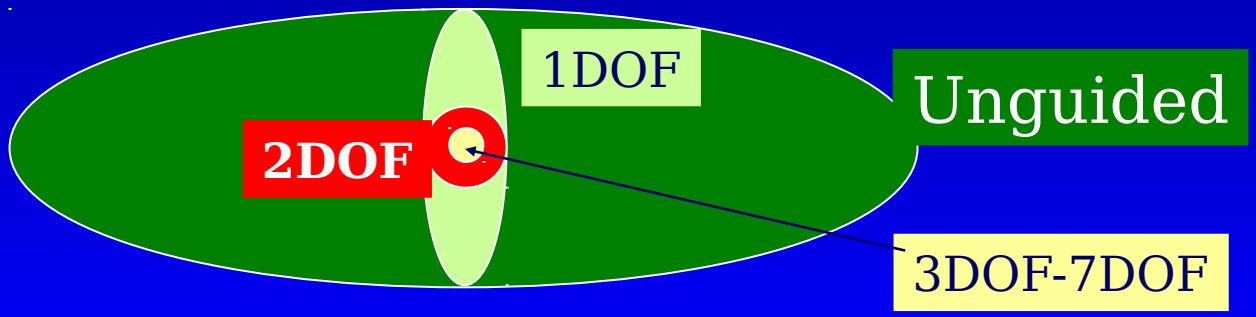
- Increase effectiveness and efficiency of cannon artillery
  - **CEP<50 meters**
  - **Reduce logistics**
  - **Increase OPTEMPO**
- Exploit large existing projectile war stocks
  - **Fuze well implementation**
  - **Reversionary mode (fuze only)**
- Corrector must still be a fuze
  - **Easy to install, program, and be robust to field handling**
  - **Volume for fuze functions**
  - **Must have a reversionary mode**
  - **Cost << $5000**



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ACCURACY Definitions

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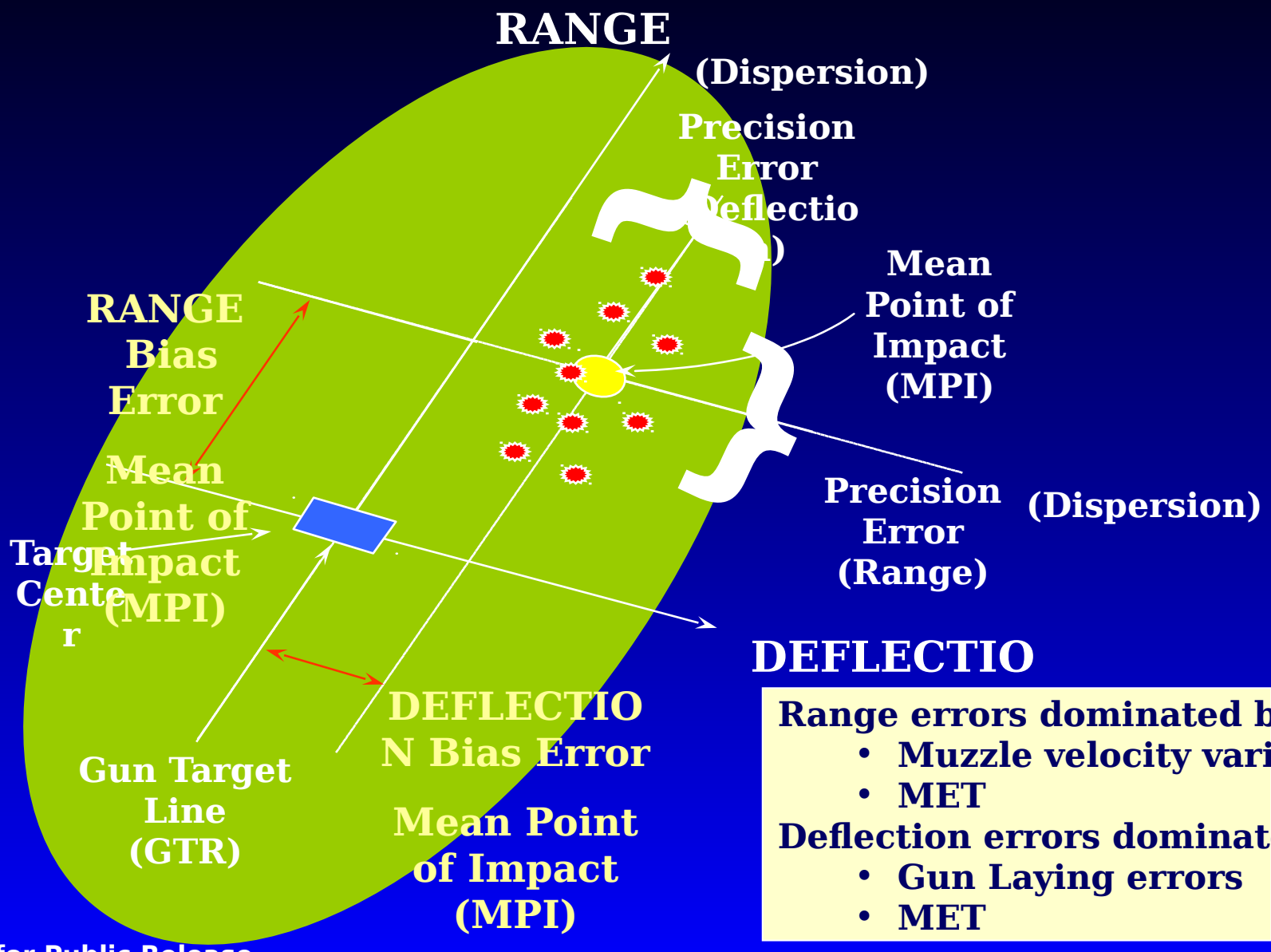

Range errors dominated by
- Muzzle velocity variation
- MET

Deflection errors dominated by
- Gun Laying errors
- MET

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Wide Potential Solution Space

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Alternate Concepts	Number of known c
1DOF- Downrange	☑ ☑ ☑ ☑
1DOF- Cross range	☑
2DOF-Decoupled	
Roll stabilized	☑
Roll rate Stabilized	☑ ☑ ☑
2DOF-Body fixed	
Roll Rate/Aerobrake (1+)	☑
Flow disruption	?
HF Fixed canard	☑
HF trailing canard / solenoid	?

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Some Examples

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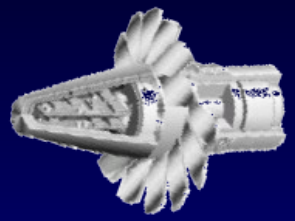
1DOF Range Correctors



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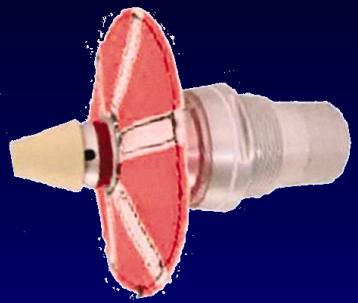
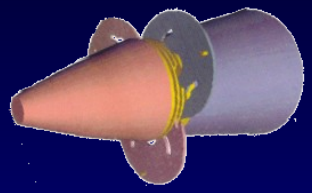


DMS



SPACIDO

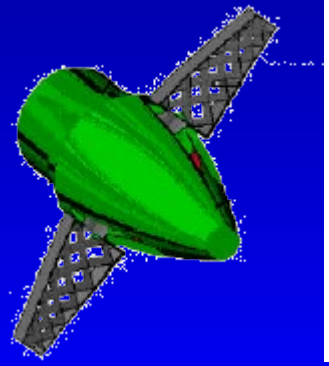
2DOF Range/Deflection Correctors

1DOF Deflection Corrector

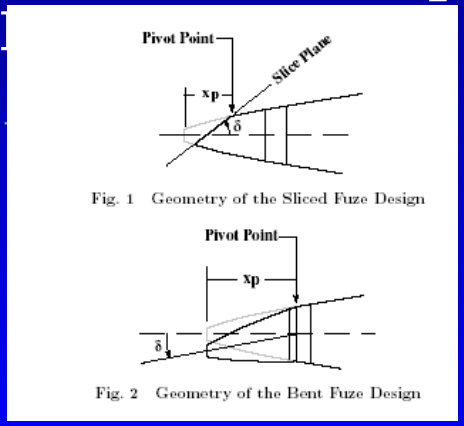
CMATD

ANSR

NSWC GI



MIT Concepts



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Theory of Operation - 1DOF-R

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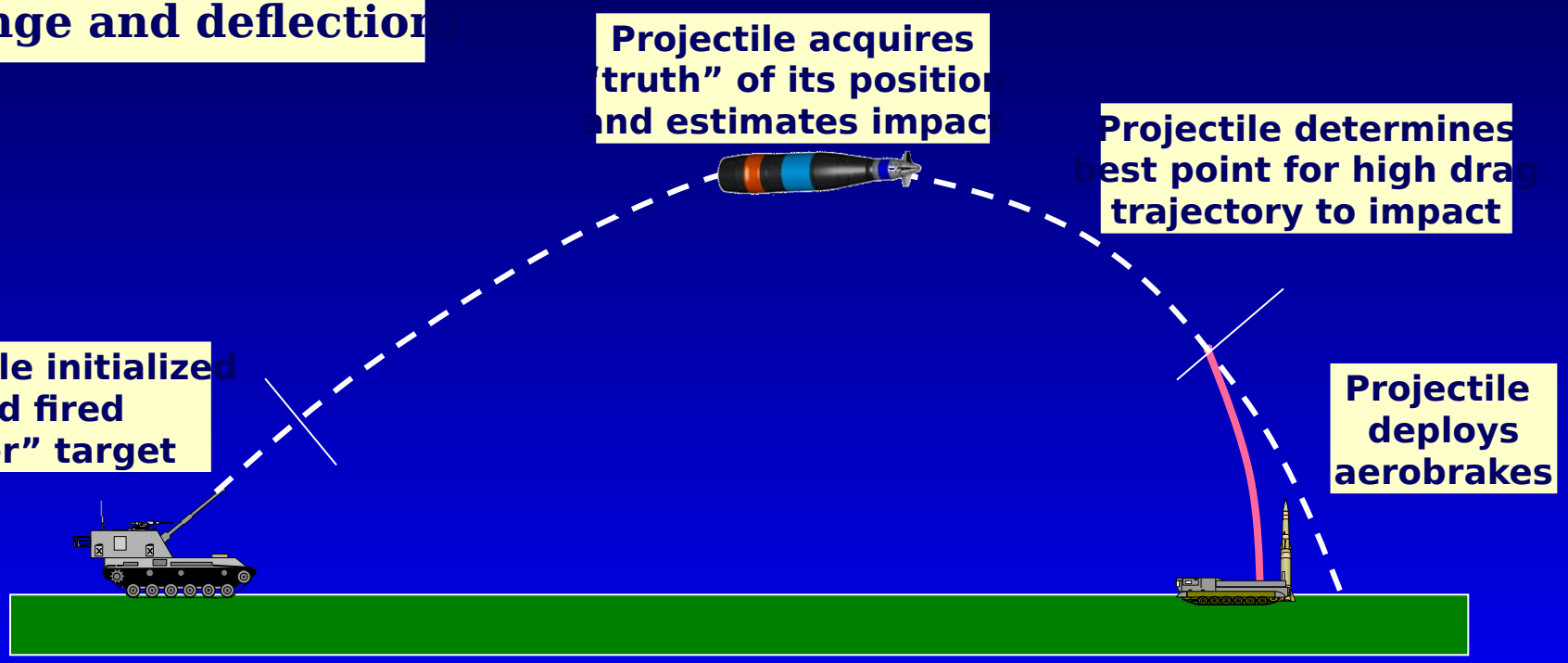
Minor modification to firing tables required (range and deflection)


Projectile acquires "truth" of its position and estimates impact
Projectile determines best point for high drag trajectory to impact
Projectile initialized and fired "over" target
Projectile deploys aerobrakes

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Theory of Operation - 2DOF

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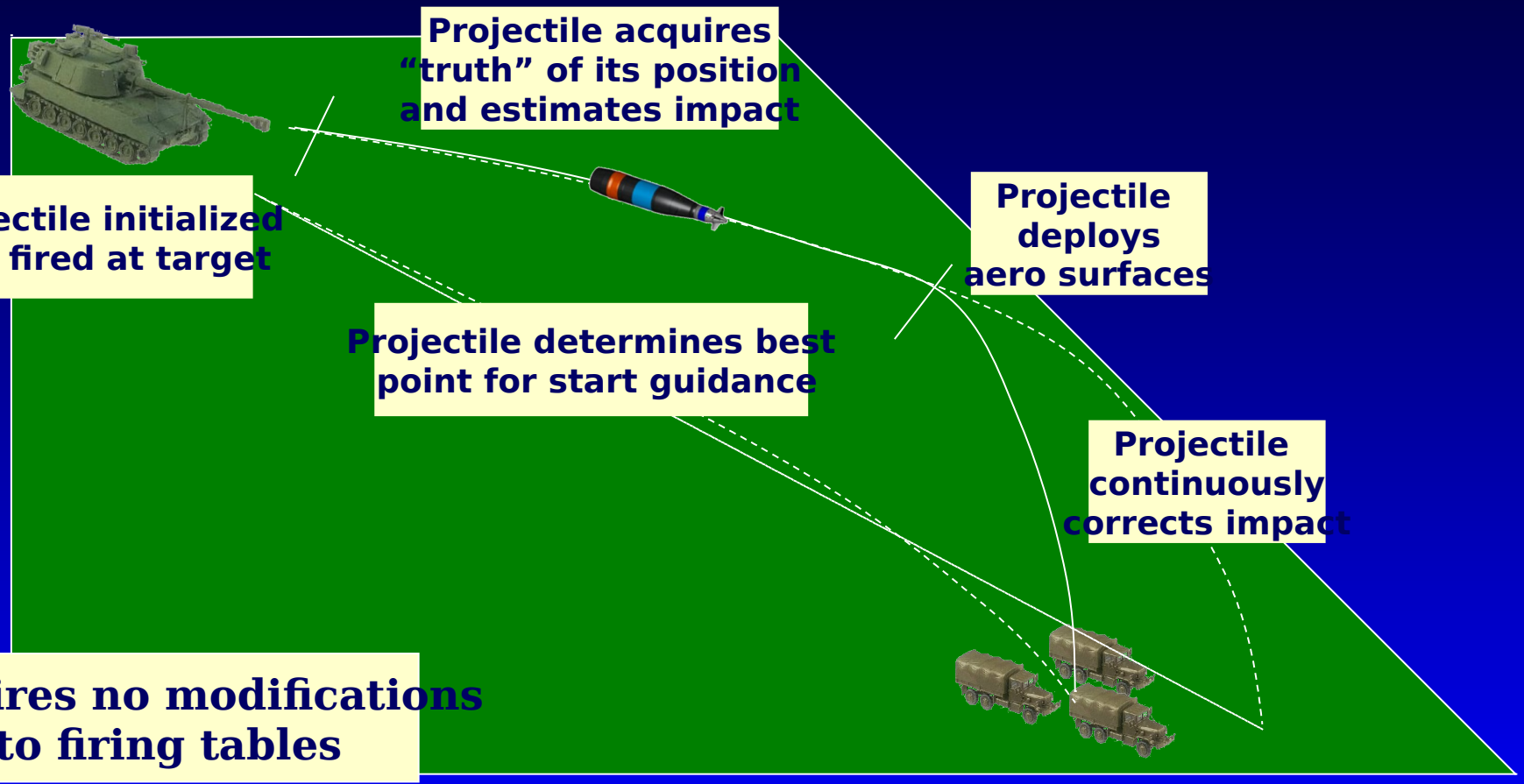
Projectile acquires "truth" of its position and estimates impact
Projectile initialized and fired at target
Projectile deploys aero surfaces
Projectile determines best point for start guidance
Projectile continuously corrects impact

Requires no modifications to firing tables

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Theory of Operation - 2DOF Control

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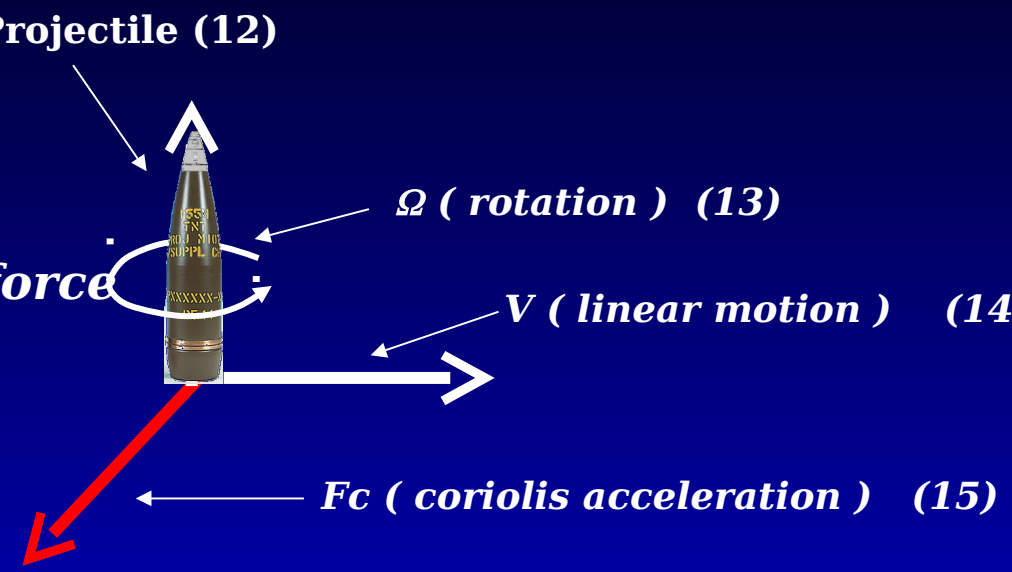
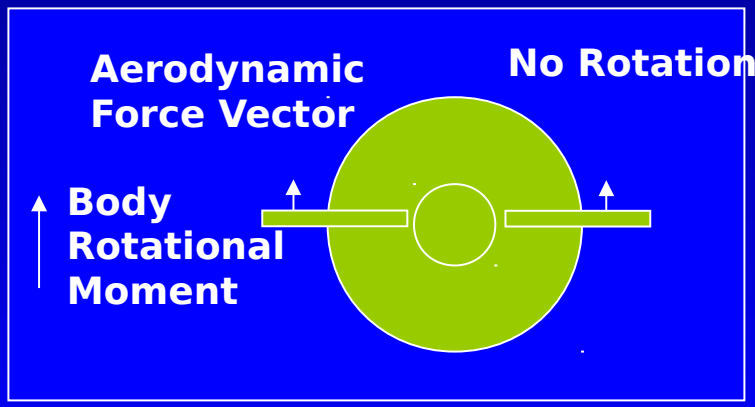
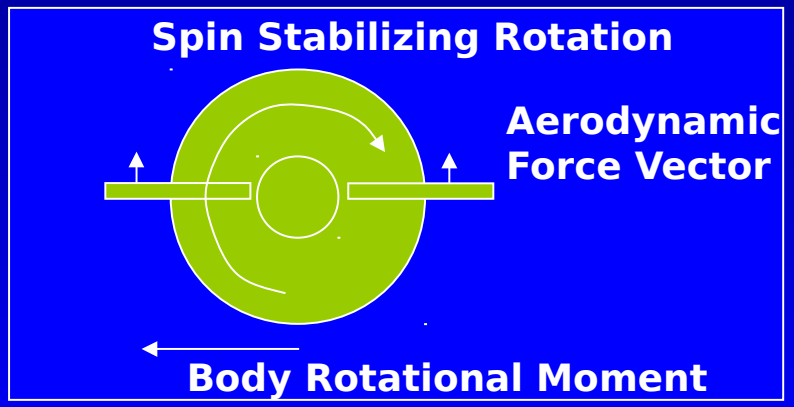
$$F_C = 2mV \times \Omega$$

F_C	*Out of plane force*
m	*Mass*
V	*Velocity*
Ω	*Rotation*







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Potential “truth” sources for Guidance

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- Ballistic
- Inertial
- Data Link Update (Command)
- GPS
- Ground Beacon Array
- Terminal Seeker
  - (seeker range, packaging, costs issues)

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Summary of "Truth" Sources for Guidance

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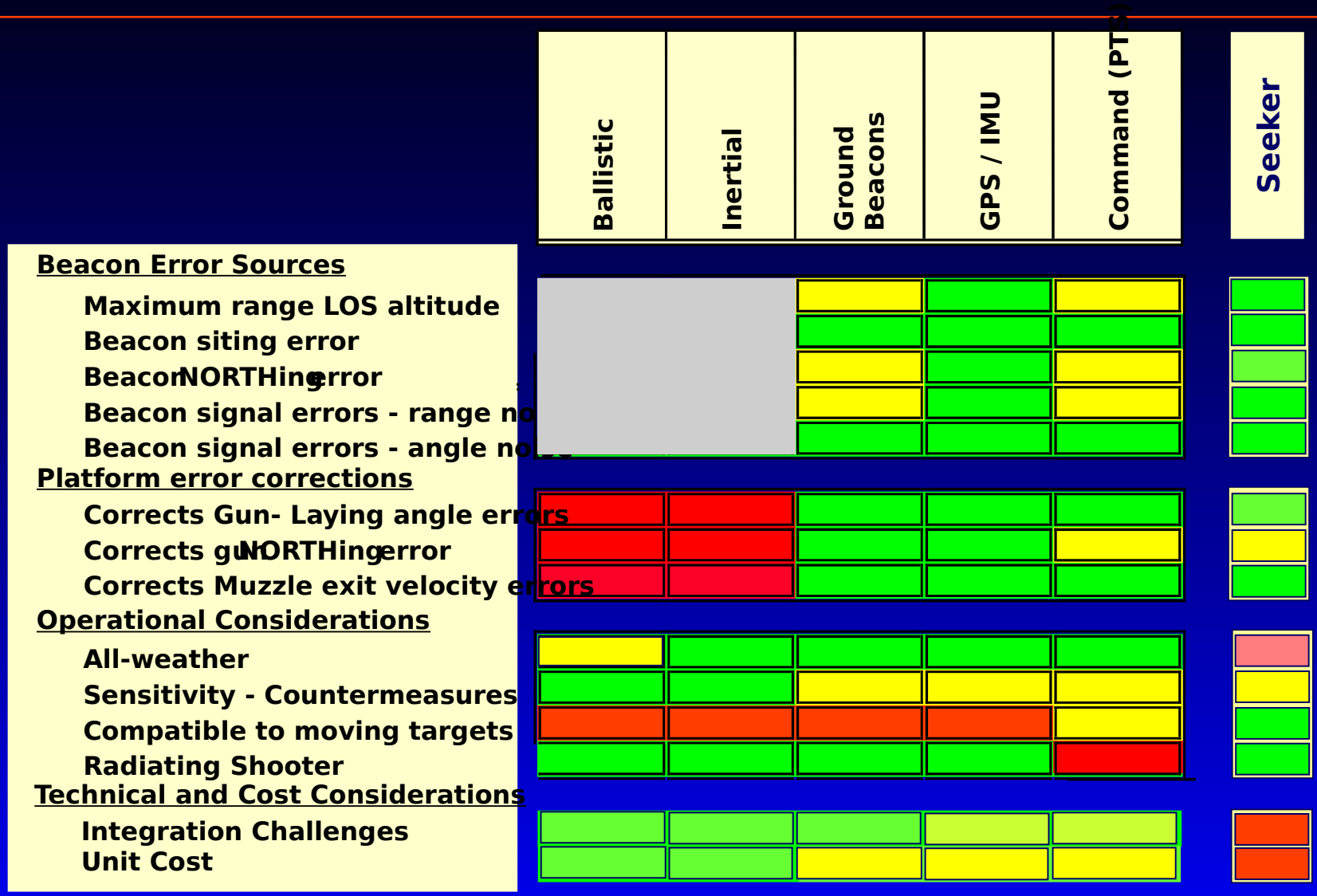

GPS or GPS/INS Appear to be Most Appropriate Trut

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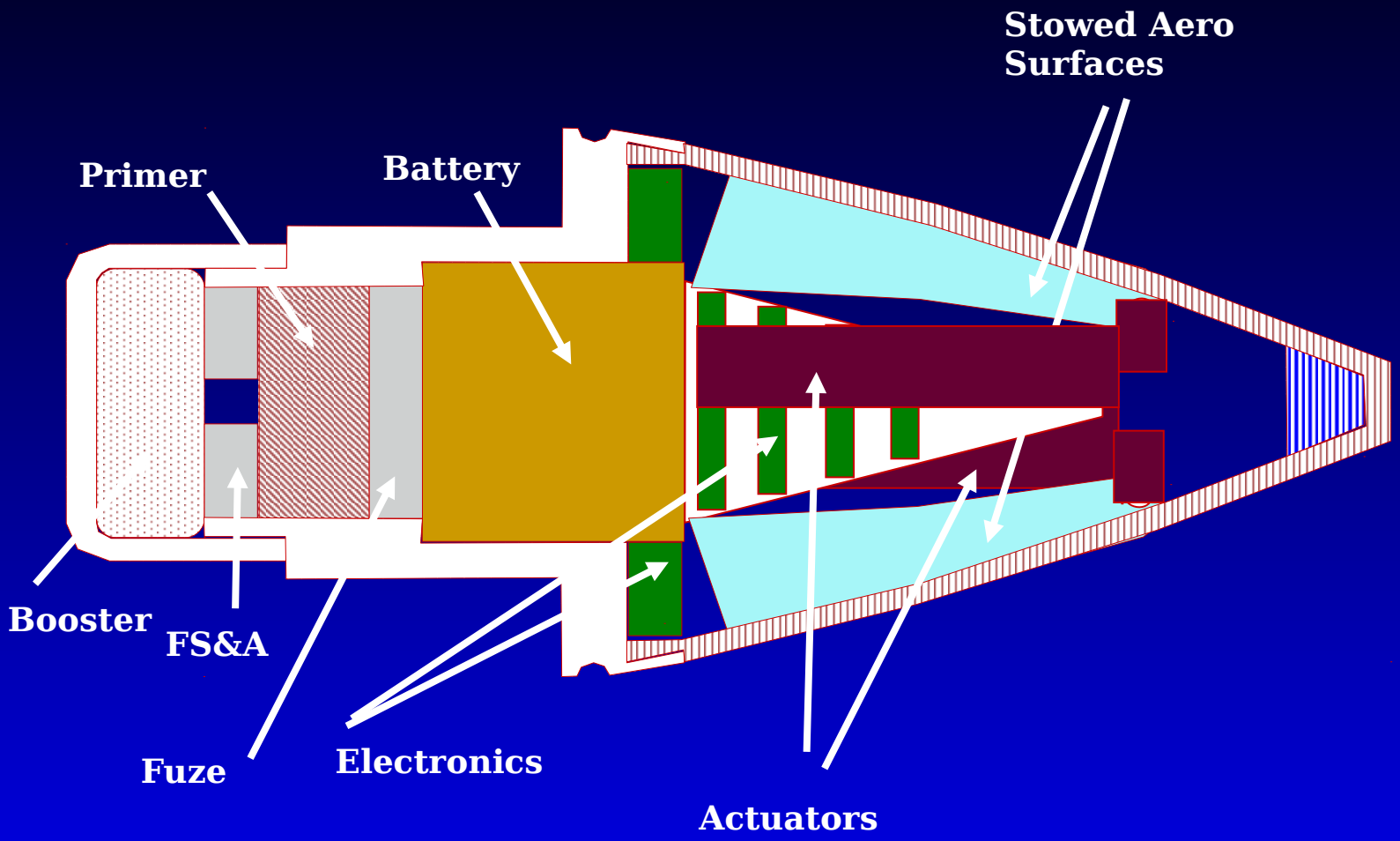
Representative 2DOF Fuze / Guidance Kit



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Various Studies Have Shown Concept Feasibility

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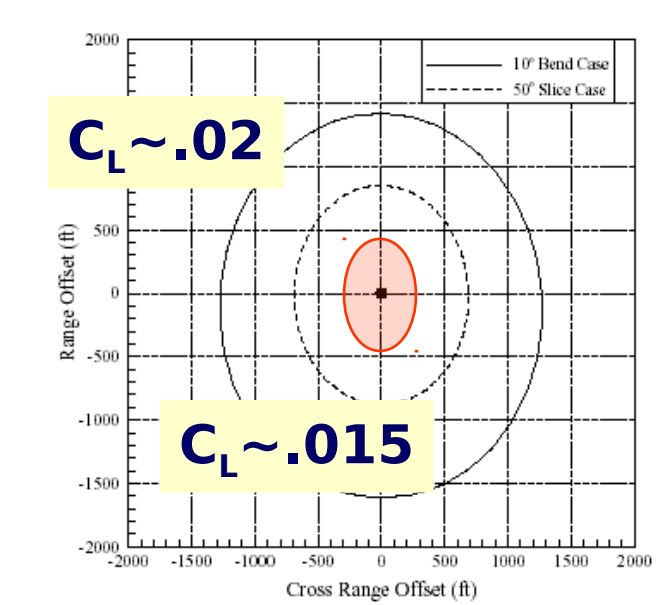

Fig. 17 Ballistic Simulation Foot Print

Reference –Aerodynamic Fuze Characteristics A.M. Budg
June 1998 MIT

	10%	33%	67%	100%
0.25				
0.5				
1.0				
2.0				
4.0				
6.0				

- Various CCF/GIF Studies have indicated sufficient Maneuverability with Low aerodynamic effect lifts.
- However, these studies widely vary as to real life implementation fidelity (winds aloft / guidance law interaction, guidance start times, actuation constraints)
- Without considering realistic winds aloft many control concepts will appear satisfactory
- But due to physics of the spinning projectile there is a practical limit to useful C_L authority

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Representative Winds Aloft

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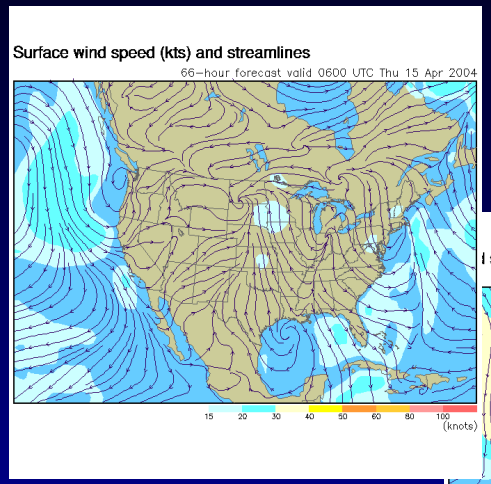
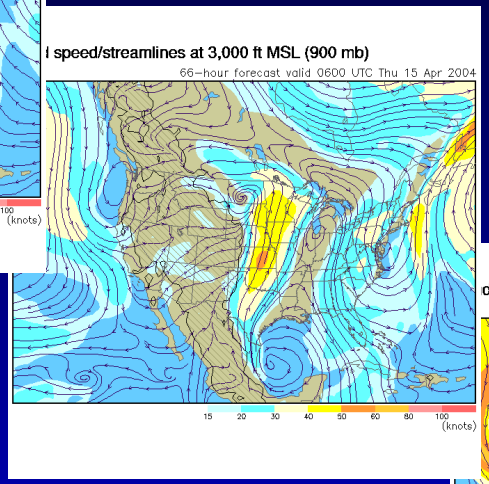
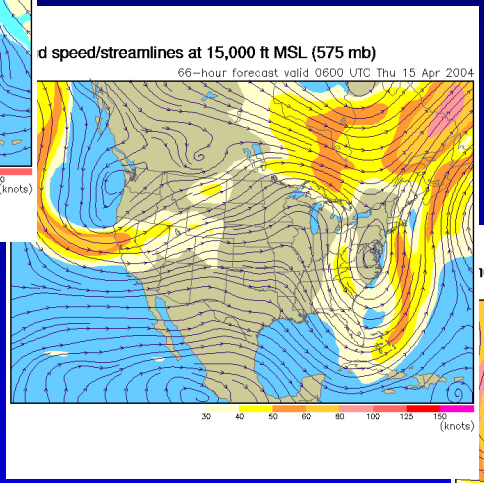


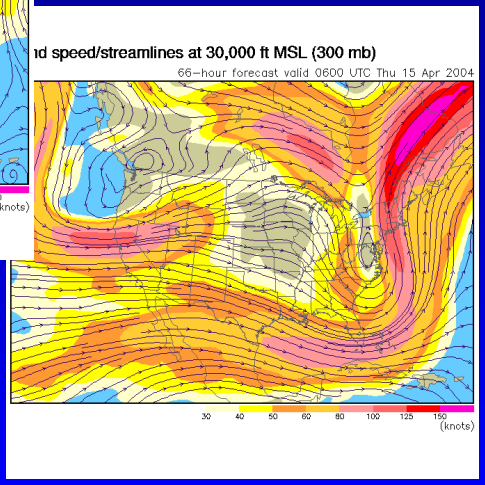
Surface



3,000 ft



12,000 ft



30,000 ft

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GIF/CCF Requirements Deconstruction

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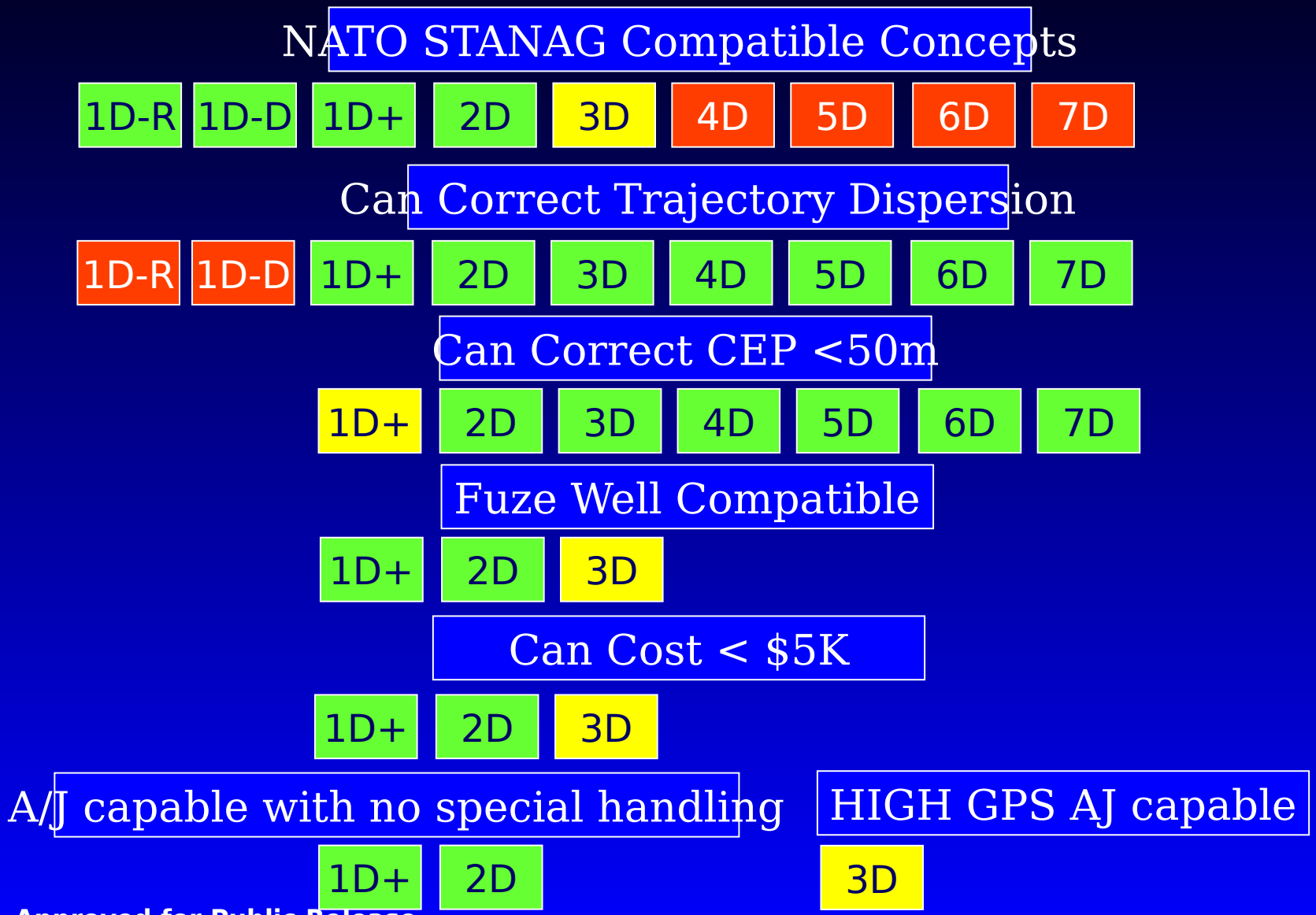

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Summary

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- Depending on desired Operational Flexibility and Cost Sensitivity, there are a number of potential solutions.

- Spiral development from the 1DOF (presently easily implementable) to the final desired operational product (2DOF or 3DOF) is an option

- GPS or GPS/INS are the most appropriate “truth” sources

- Joint service kit requires 2DOF or 3DOF kit at minimum

- To avoid developing new ballistic tables, nose weight/shape should conform to NATO STANAG OML

- Implementation of actuation and power source are the technical challenges

- Packaging of a gun hardened unit is also a challenge

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